Spatial and Temporal Migration of a Landfill Leachate Plume at Norman Landfill Research Site

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http://ok.water.usgs.gov/norlan/index.html

There will be 6 more talks over research from Norman.

- Isabelle Cozzarelli -- “Long- term biogeochemical evolution of the leachate plume”
- Joe Suflita – “Microbial activity and its influence on organic matter quality”
- Victoria Parisi -- “The implications for anaerobic methane oxidation”
- Bob Eganhouse – “Endocrine disrupters” and new technology for the determination of nonylphenol isomers”
  Michelle Lorah – “Natural attenuation of landfill contaminants at the ground-water/surface-water interface”
- Tara Kneeshaw – “Kinetic controls on sulfate reduction at hydrologic interfaces”

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The Norman Landfill Site

- Selected to gain a greater understanding of the hydrological, biological, geochemical processes controlling the fate of landfill contaminants.
- Site is a model for approximately 100,000 closed and active landfills across the United States.
- Historical research dating back 30 years.
- Site serves as a environmental laboratory for process-oriented research.

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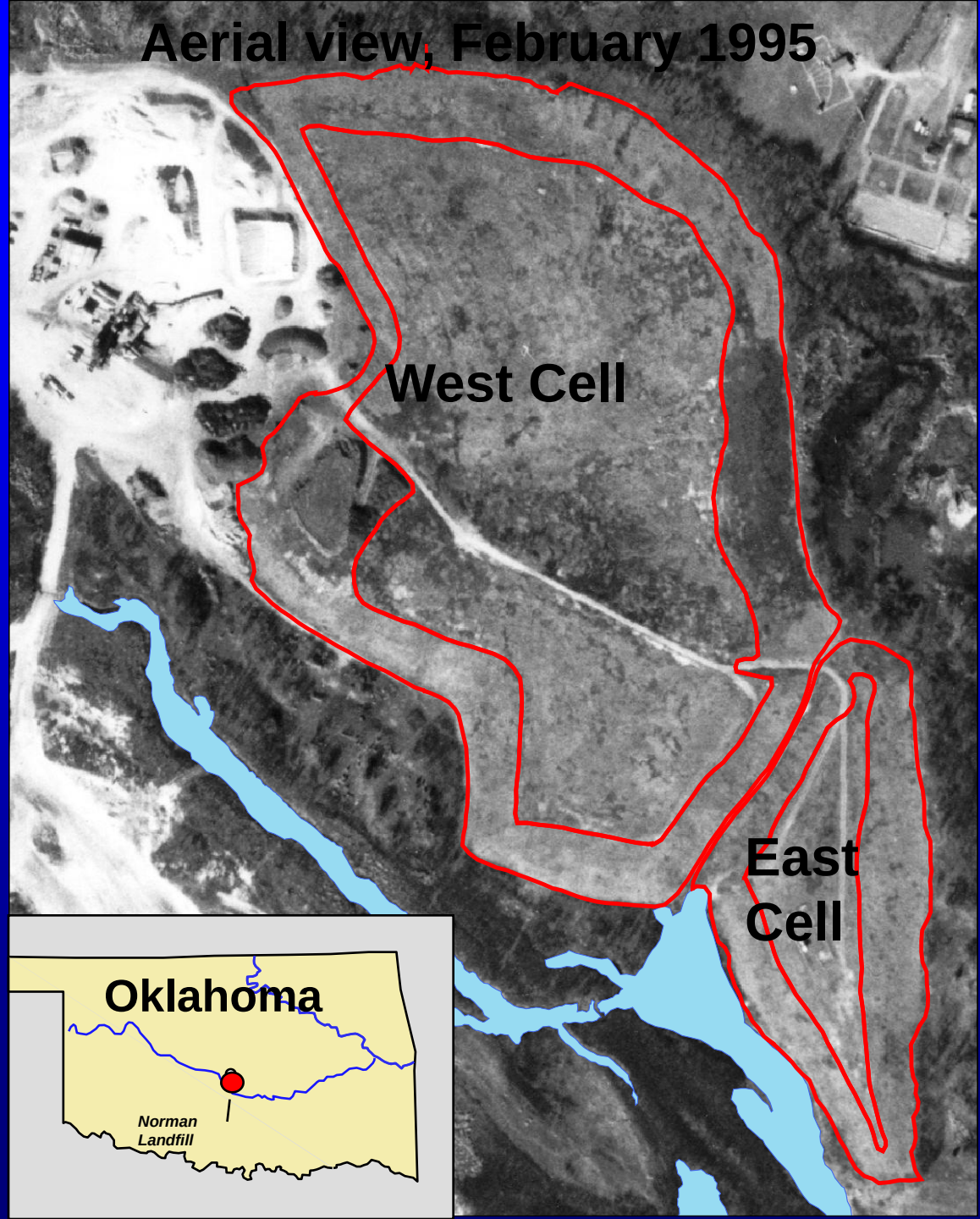
Norman Landfill

- Municipal landfill operated from early 1900's to 1985
- Accepted unrestricted solid waste
- Unlined
- Closed in 1985 covered with clay and vegetation
- Selected as point-source research site in 1994



- The Canadian River Alluvium consists of unconsolidated layers of clay, silt, sand, and gravel transported and deposited by the River (median k = 6.6×10^{-5} m/s).
- Groundwater velocity, medain k is 13 m/year, aquifer base 50 m/year.
- Shallow depth to water.
- These river valleys are subject to periodic flooding, making such land low in cost for public uses such as landfills or parks.

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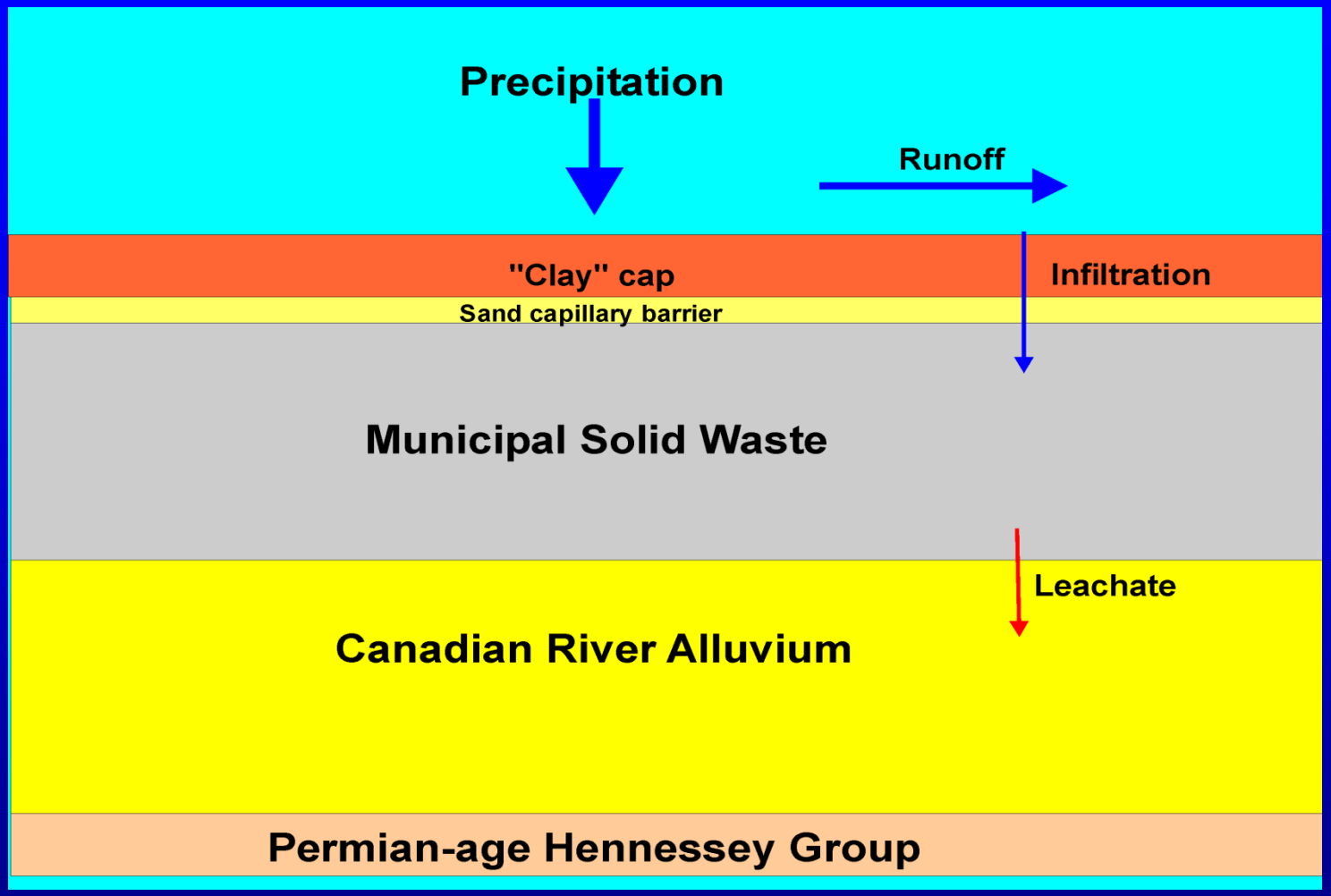

The old Norman Landfill has no liner or leachate collection system.
A leachate plume has developed.

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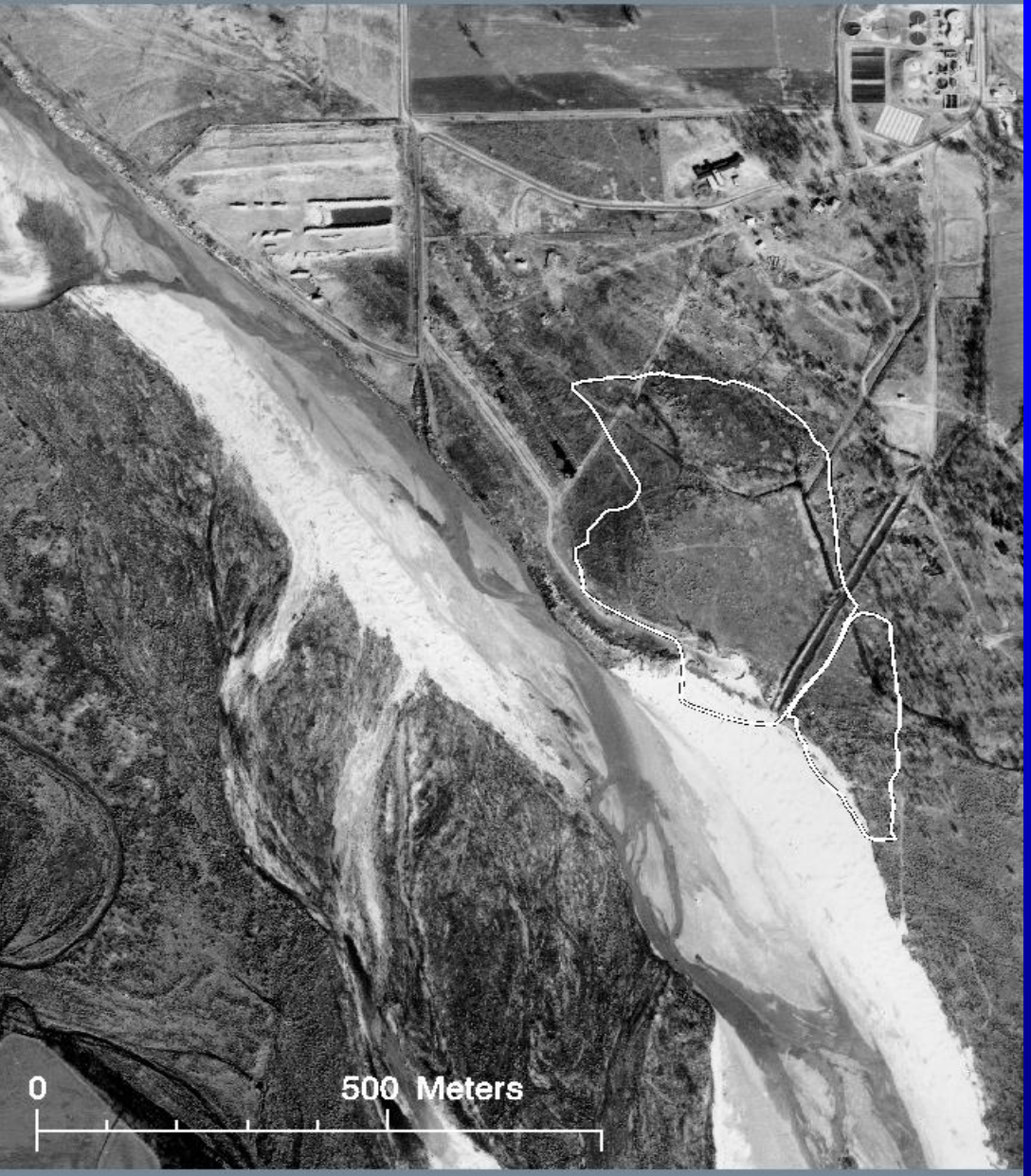

EXPLANATION

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Norman Landfill, November 1966

Norman Landfill Showing Closure Operations in 1985

WEST
CELL
EAST
CELL
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February 1995
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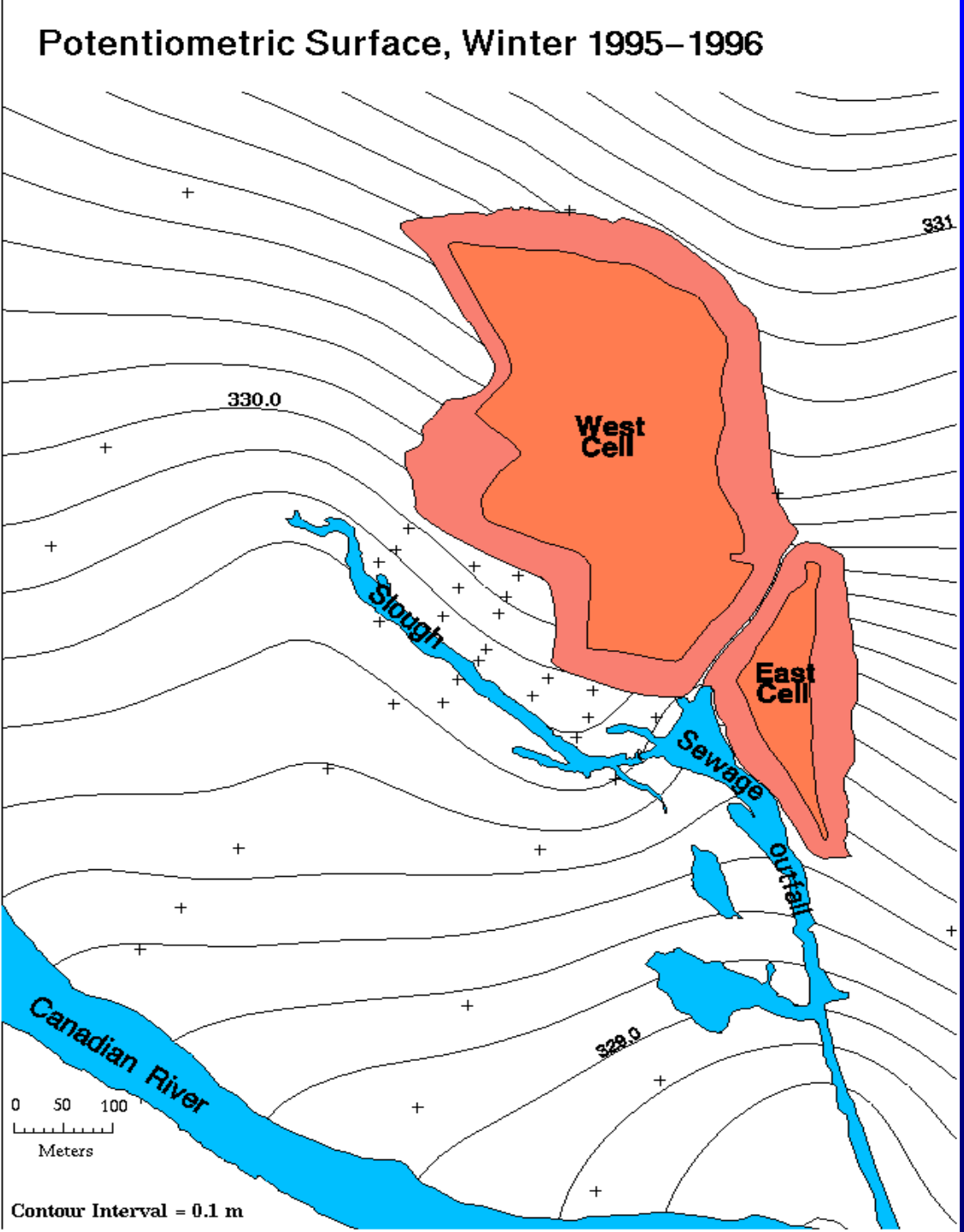
Oklahoma City, Oklahom

June 2003

June 2006



Potentiometric Surface at Norman Landfill, Winter 1995-96

- Each line represents 10 cm.
- Direction of GW flow.
- Site includes a natural wetland "The Slough".
- Hydraulic gradient: North of landfill 2.8 m/km, South of landfill 1.4 m/km.

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Mapping the Spatial Extent of The Leachate Plume

- **1996, Water-Resources Investigations Report 01-4168, hydrogeology and leachate plume delination.**
- **2000, Thesis work about the characteristics of the Canadian River Alluvium by DeHay, Paxton, and Marston.**
- **2008, recent field sampling.**

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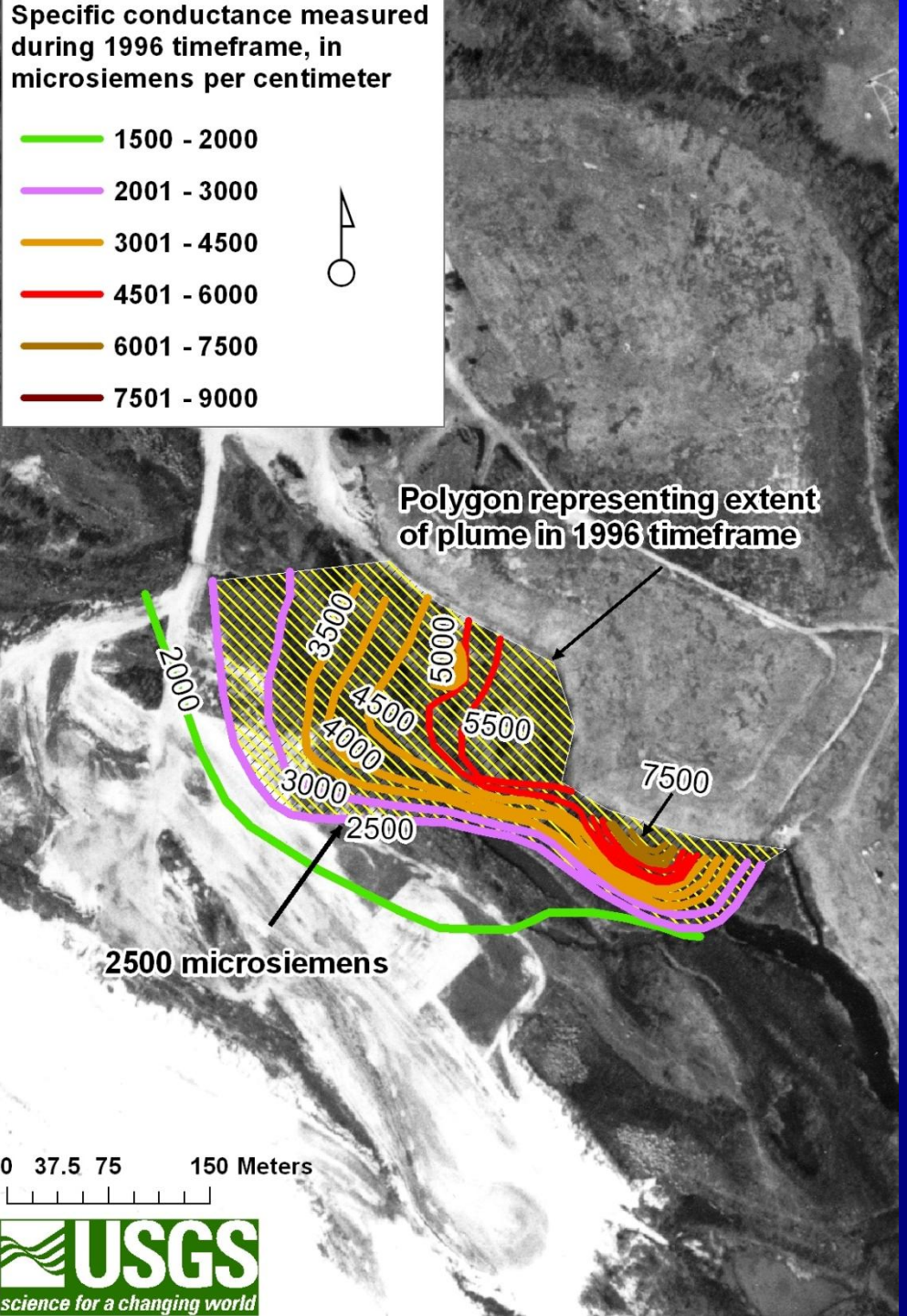
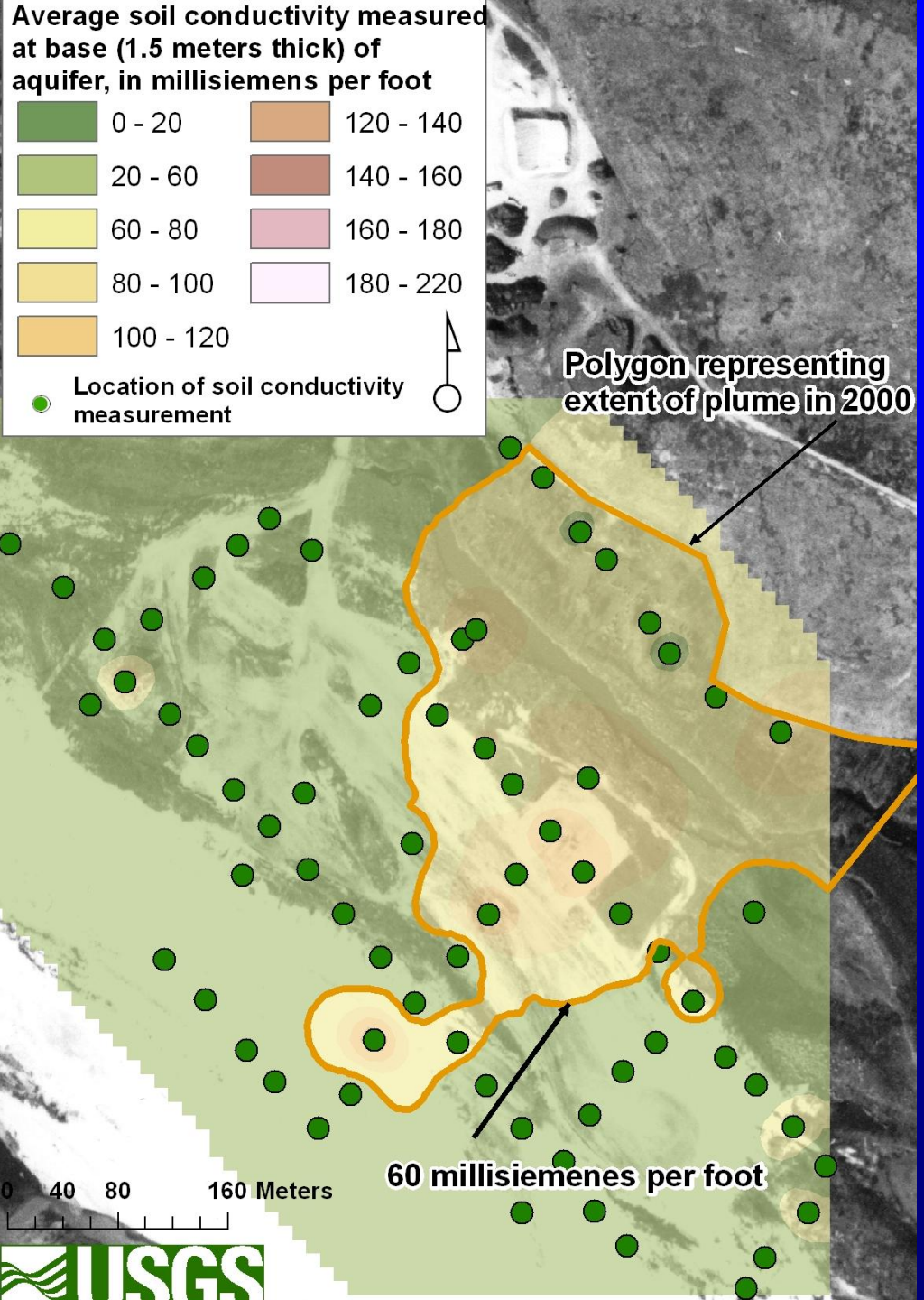


1996 Time Period

- ✓Specific conductance contours were digitized.
- ✓Southern landfill toe used to represent the up-gradient edge of plume.
- ✓Contour value 2500 used to represent down-gradient edge of plume.
- ✓Calculated area , 50,793 m^2



2000 Time Period

- ✓Geoprobe used to measure continuous soil conductivity.
- ✓Average soil conductivity calculated.
- ✓Southern landfill toe used to represent the up-gradient edge of plume.
- ✓Contour value 60 used to represent down-gradient edge of plume.
- ✓Calculated area, 95,639 m^2

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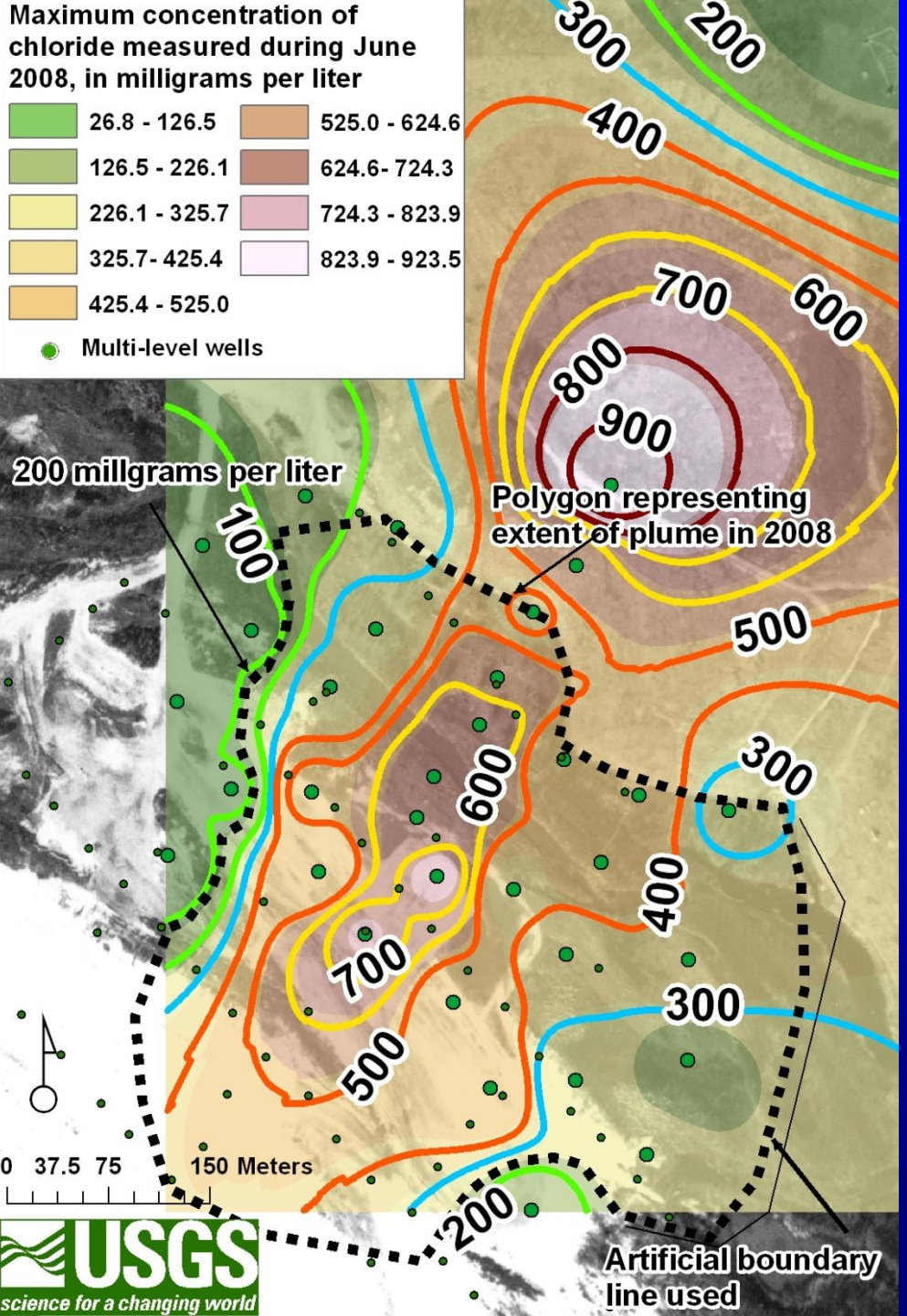
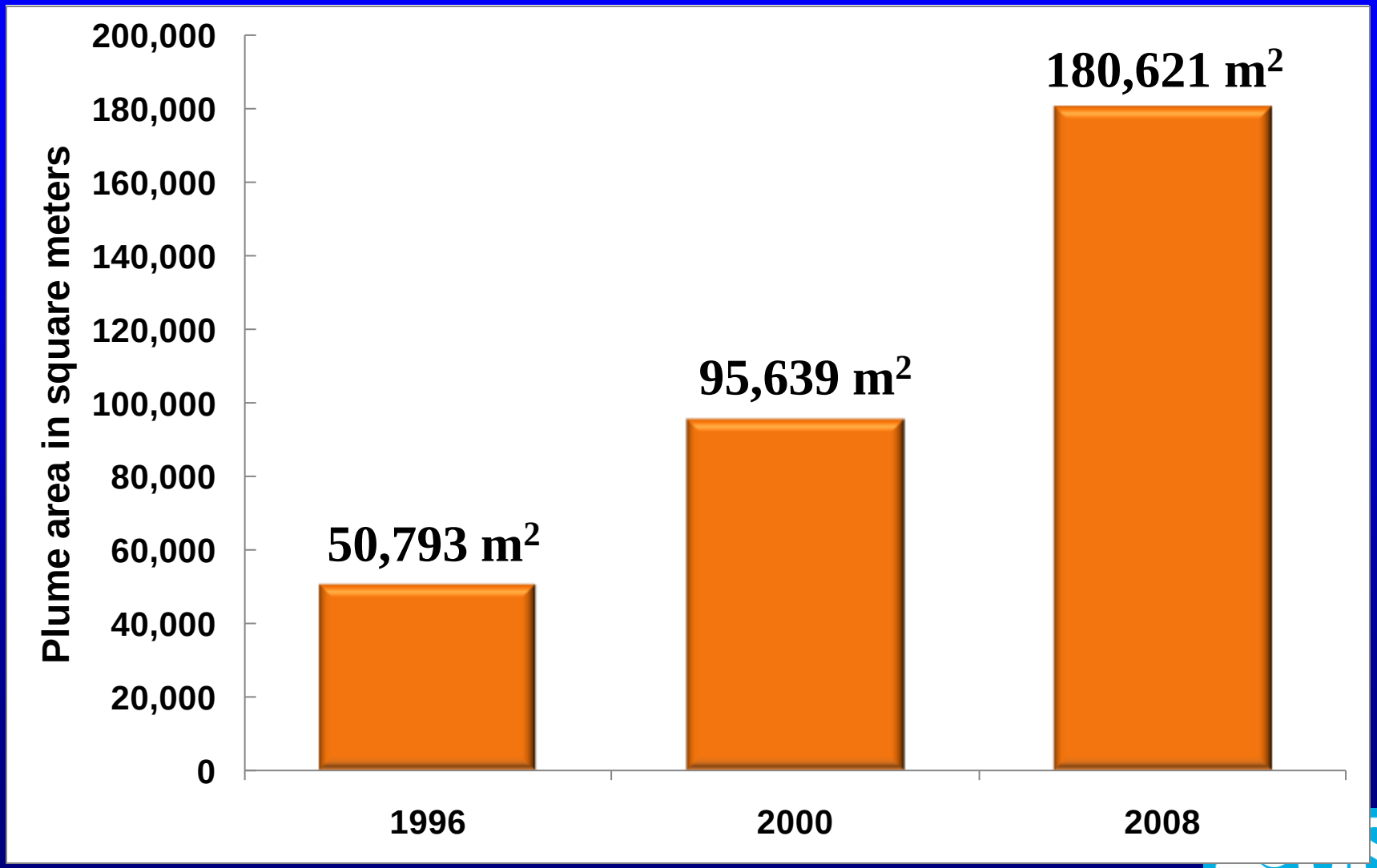


2008 Time Period

- ✓Collect water samples from multi-level wells.
- ✓Southern landfill toe used to represent the up-gradient edge of plume.
- ✓Contour value 200 used to represent down-gradient edge of plume.
- ✓Calculated area, 180,621 m^2

Constituent	Canadian River Alluvium	Norman Landfill Plume	Other Landfill Plumes
Chloride (mg/L)	5-100	200-1200	10-3800

Plume Area in 1996, 2000, and 2008



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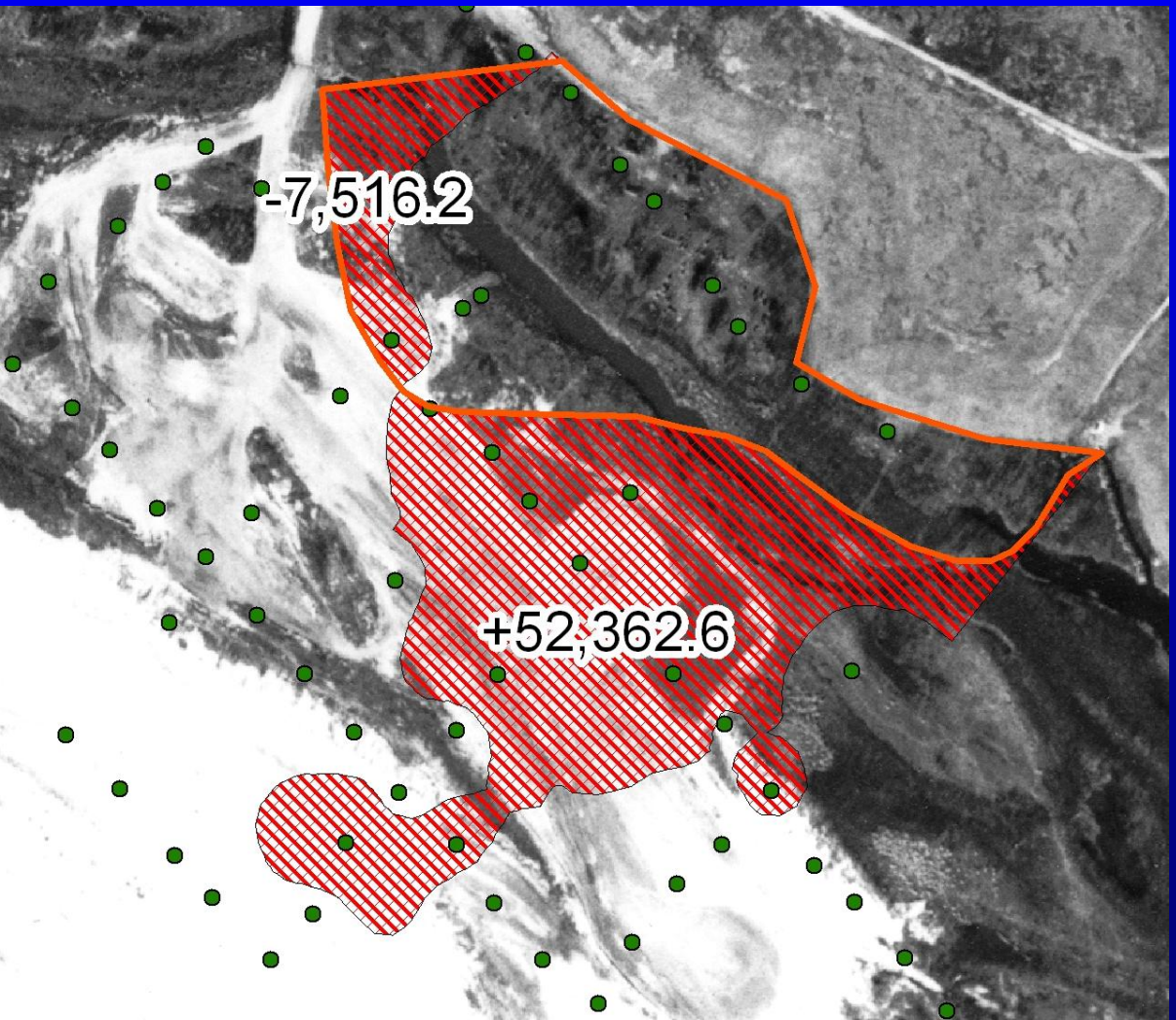
Migration of Plume in 2D
1996 to 2000



- Symmetrical difference ($-7{,}516.2\ m^2 + 52{,}362.6\ m^2$) $= 44{,}864.4\ m^2$
- **88.3** percent increase, $(b - a) / a * 100$

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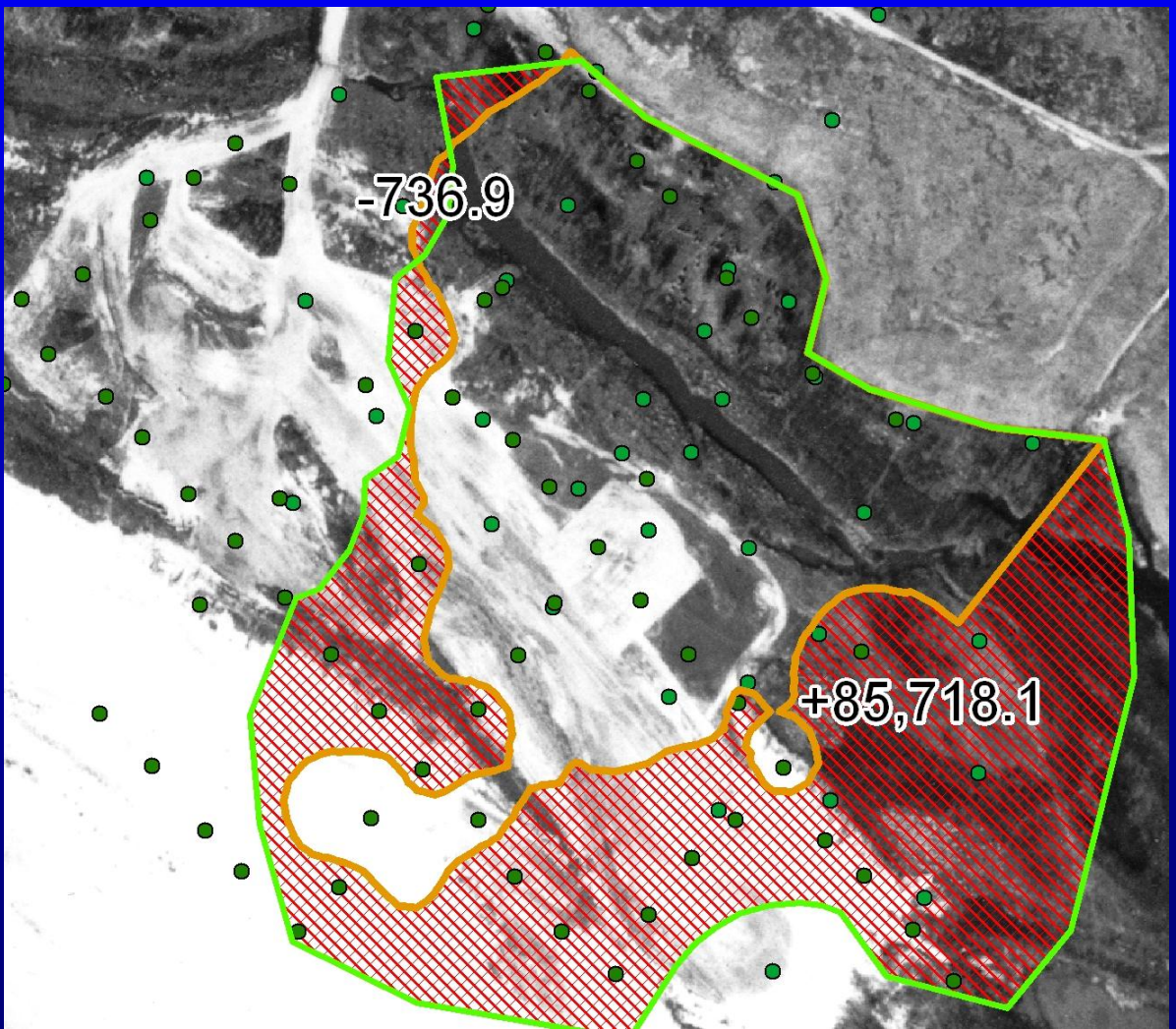
Migration of Plume in 2D 2000 to 2008



- Symmetrical difference (-736.9 m^2 + 85,718.1 m^2) = 84,981.2 m^2
- **88.9** percent increase, (b - a) / a * 100

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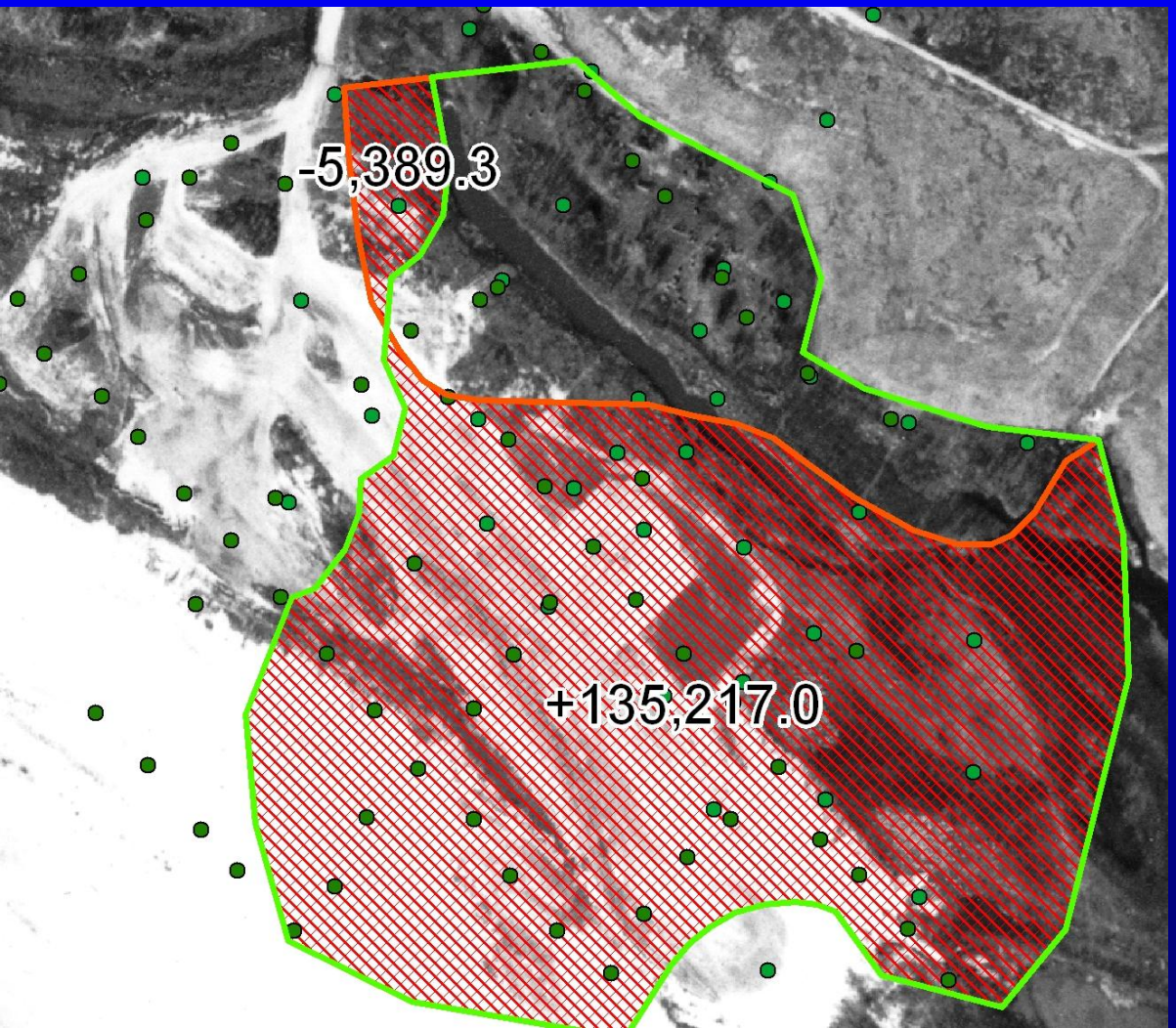
Migration of Plume in 2D 1996 to 2008



- Symmetrical difference (-5,389.3 m^2 + 135,217.0 m^2) = 129,827.7 m^2
- **255.6** percent increase, (b - a) / a * 100

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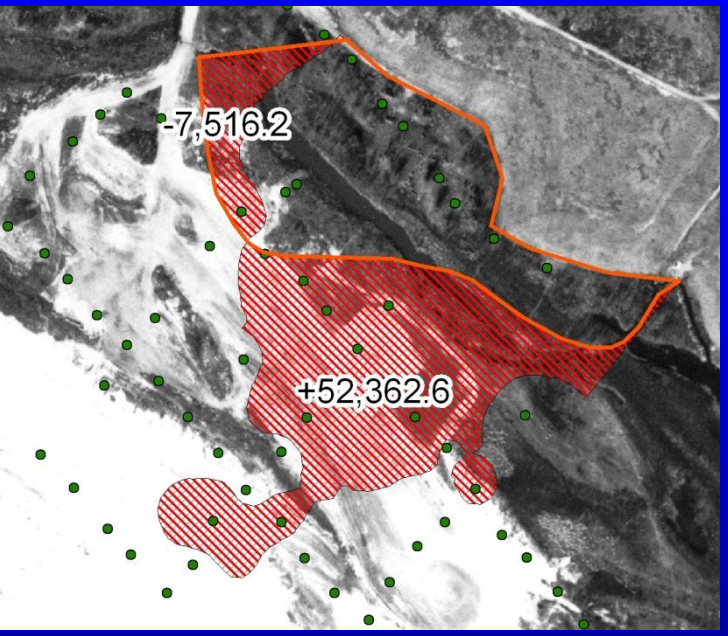
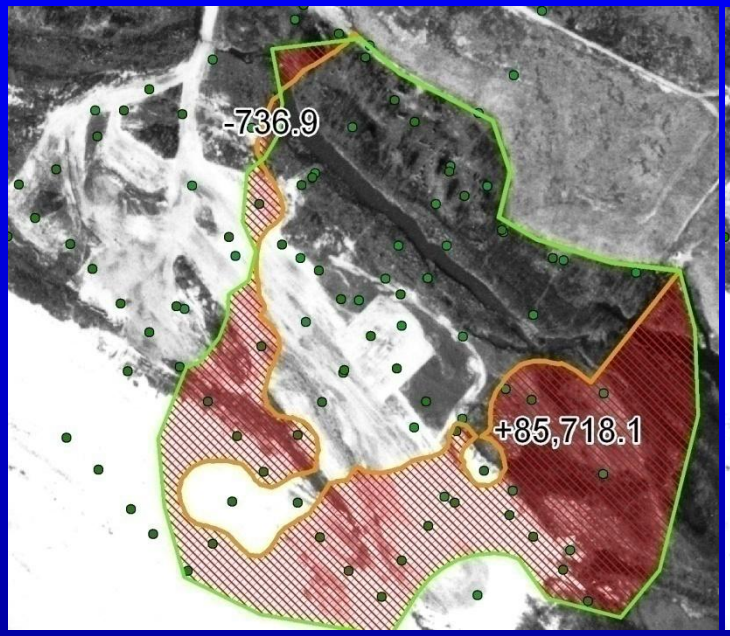
Aerial Rates of Plume Migration

1996 to 2000



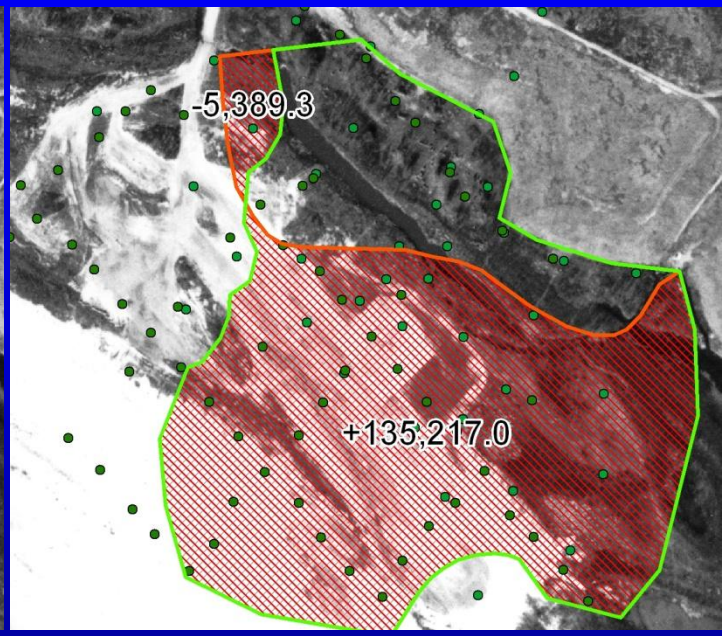
- 30.7 m^2/day or 1.13 hectares/year

2000 to 2008



- 29.1 m^2/day or 1.05 hectares/year

1996 to 2008



- 29.6 m^2/day or 1.10 hectares/year

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Summary

- Introduction of research site.
  - Background on the landfill.
  - Characteristics of the site.
- A leachate plume exist and from 1996 to 2008 has expanded at an aerial rate of 29.6 m^2/day or 1.1 hectares/year.
- http://ok.water.usgs.gov/norlan/

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